The color picture tube

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*The **television** and the **computer** have taken the world by storm in the second half of the twentieth century and have brought about great changes in many aspects of our lives. Every day, people all over the world watch television and every day, millions of computer monitors are used in a wide cross-section of applications.*

It is the color picture tube that displays the images.

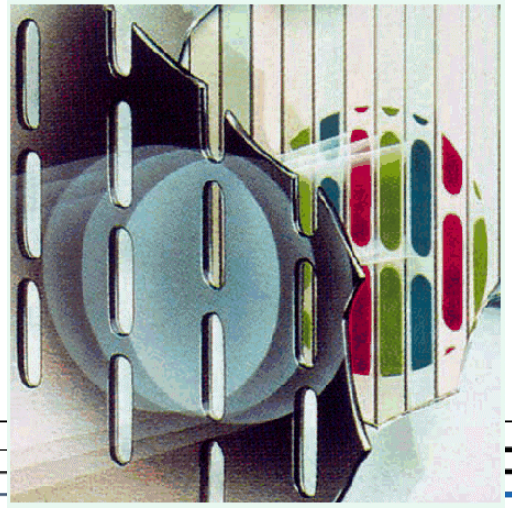
Millions of picture tubes of different sizes have been manufactured to date. Although various other technologies and systems have been developed over the years, the color picture tube is still the main device used all over the world today, and this looks set to remain so for a long time to come.

The color picture tube

How does the color picture tube work?

A color picture tube consists mainly of a glass bulb with a picture screen at the front and an electron gun and a deflection coil at the back. The picture screen is coated internally with a light-sensitive (fluorescent) layer of phosphors consisting of red, green and blue dots or lines. The color image is composed from these three primary colors, which can then be blended to produce any color.

At the back of the tube (known as the 'neck') is the electron gun containing three cathodes, one each for the red, green and blue signals. The cathodes are coated with a substance that emits electrons when it is heated. The beams of emitted electrons are focused by the metal parts of the electron gun, which are connected to different voltages and hence act as a lens. The screen is bombarded by high-speed electrons that cause the screen's phosphor coating to light up at the points where the electrons hit it.



Inside the picture screen, approximately 10 mm in front of the phosphor coating, is a thin metal plate with a pattern of small holes. This is called the 'shadow mask.' Its function is to ensure that the electrons from the three separate cathodes hit the correct phosphor on the screen behind the shadow mask.

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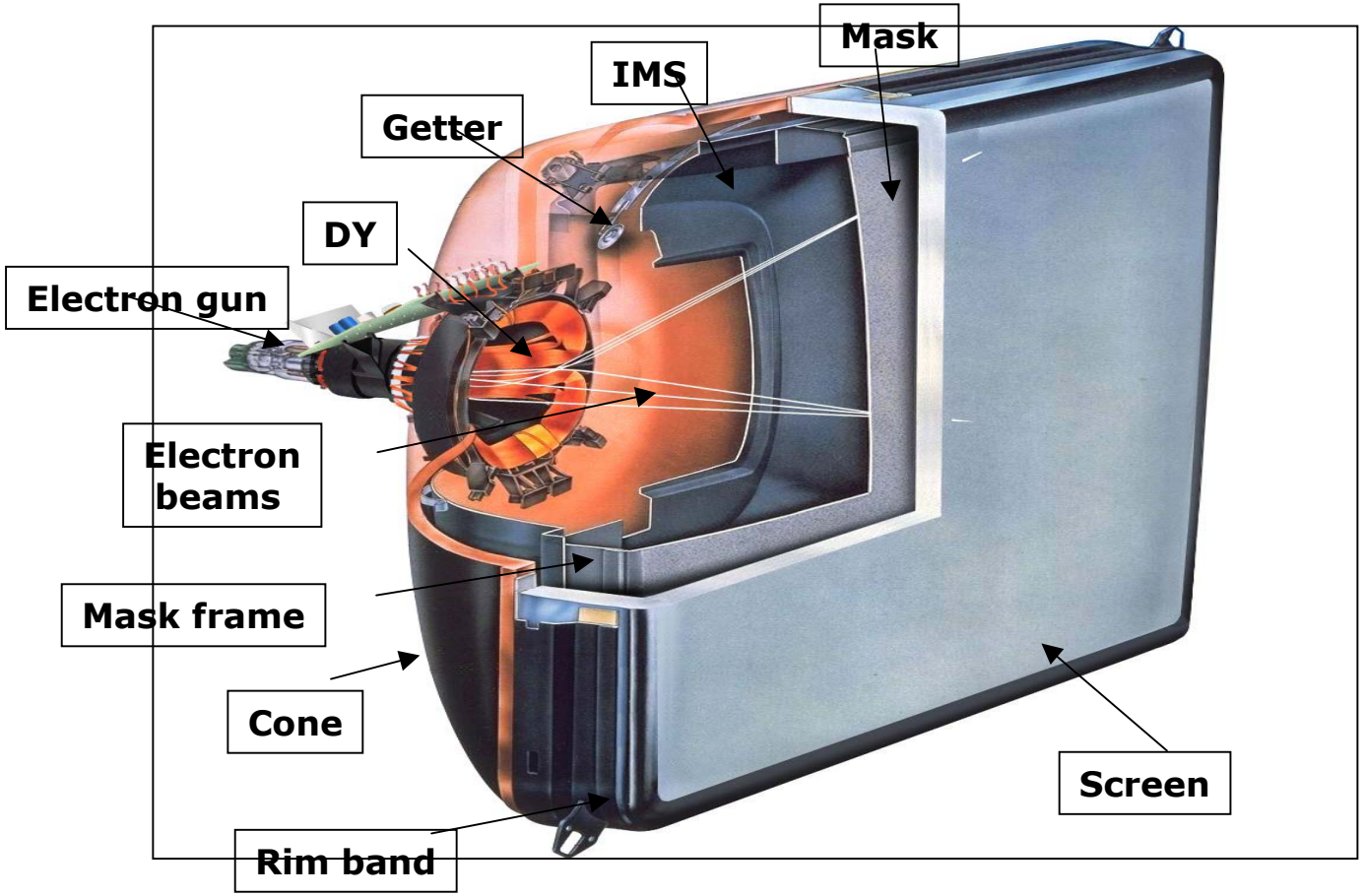
Television

All television systems are based on the principle that an image recorded by a camera is converted into an electrical signal, which is transmitted via a transmission channel and is reconverted into an image at the receiving end.

At the transmitting end, a picture (split into a red, green and blue part) is recorded by a camera, which scans the picture dot by dot. The camera emits an electrical signal, the size of which at any moment is a measure of the brightness of the picture element with respect to the red, green and blue scanned at that moment.

The picture is scanned in horizontal lines, from left to right, as you would read a piece of written text, then the next line down, and so on, to the bottom of the picture. The transmission of moving pictures requires the repetition of this process many times a second. In this way, the camera can convert the entire brightness structure of the picture into a varying electrical voltage, the video signal.

What does our end product look like?



Cutaway model of a color picture tube

Explanation of terms

Screen-pressed glass part - on the inside coated with light-sensitive powders.

Cone-the back-side glass part - during tube making, the screen and the cone are joined with enamel paste.

Electron gun (including 3 cathodes) - main function is to generate electrons and to focus them in small beams.

Deflection Yoke/Unit/Coil - main function is to deflect the three electron beams in horizontal and vertical direction to have electron beams all over the screen.

Mask - makes sure the electrons are selected for the correct phosphor.

Mask frame - mechanical suspension between the screen and the mask.

IMS (Inner Magnetic Shield) - prevents the deflected electrons from being influenced by the earth's magnetic field, or other magnetic objects.

Getter - ensures that the tube 's vacuum stays at the right level during its life time.

Rim band - guarantees safety of the evacuated tube and is the mechanical interface to the set/monitor.

Computer

In the computer monitor, the picture is scanned in the same way as in the television set, but the number of picture lines and frames per second can vary greatly. Picture tubes are essentially no different from those for television use. The information from the video signal is received at the electron gun of the picture tube via a transmission channel (television) or in the computer monitor by the computer itself.

The luminous intensity of the electron beams from the electron gun is modulated by this information. Each of the three beams receives the information of only one color.

The three beams are simultaneously deflected by a deflection coil which surrounds the outside of the picture tube neck.

The deflection coil consists of two sets of coils, one of which generates a vertical oriented magnetic field, the other a horizontal one. These two fields deflect the electron beams in a horizontal and vertical direction respectively.

Three coinciding raster pictures are consequently projected onto the picture screen and this is how the image originally recorded by the TV camera or generated by the computer is ultimately reproduced on the picture screen.

The inside of the glass cone connecting the picture tube to the neck is coated with a conductive layer from which the electrons are led back from the screen. The picture tube is evacuated (vacuum) to prevent the electrons colliding with gas molecules and consequently losing their energy and scattering, and also blasting ions out of the gas molecules which lowers the life of the picture tube. Optical coatings can be applied to the outside of the screen of the tube to get anti-reflective and anti-static properties.

How is a color picture tube made?

As seen previously, the main elements of a color picture tube are a glass screen (panel), a shadow mask, a glass cone, an electron gun, a metal inner cone and a deflection coil. Before the screen is prepared for the application of the light-sensitive phosphors, the shadow mask is attached to it; together, the screen and the shadow mask then constitute what is known as 'mask/screen combi.' From this manufacturing step onwards, the shadow mask and the screen belong together; neither may be replaced in the further manufacturing process, in which great precision, to a few thousandths of a millimeter, is required.

The light-sensitive phosphor that is applied to the inside of the screen ultimately forms dots or vertical lines in the colors red, green and blue, arranged side by side. In this application process, the so-called 'flow-coat' process, a suspension of green phosphor is poured onto the screen first. After this has dried, the shadow mask is mounted in the screen and the light-sensitive green phosphor is exposed with the aid of an ultraviolet (UV) light source.

The phosphor is hardened behind the parts in the mask that transmits the light. The shadow mask is then removed and the unhardened phosphor is rinsed from the screen, collected and recycled for further use. The screen is now covered with hardened dots or vertical lines of green phosphor.

The blue and red layers of phosphor are then applied in the same manner. In the case of the so-called 'matrix' tubes (black between the lines or dots of color, for greater contrast), a black layer is applied first followed by the colored phosphors. After all three color phosphors have been applied, the entire pattern is coated with a layer of aluminum. This aluminum conducts the electrons and also reflects the light emitted inwards by the fluorescent phosphor (mirror effect).

How is a color picture tube made?

In the meantime, the inside of the glass cone has been coated with a conductive layer. An enamel paste is applied to the cone's edge, after which the cone and the mask/screen combi, including a metal inner cone which acts as a magnetic shield, are enameled together at a high temperature. The electron gun is then sealed into the cone's neck and a vacuum is formed inside the bulb at a high temperature, after which the bulb is sealed up. The bulb has now become a tube.

A gas binder (getter), mounted in a previous manufacturing step, is evaporated by means of electromagnetic heating in order to bind the residual gas atoms by chemical reactions. The outside of the picture tube's cone is coated with a conductive layer and a metal rimband is heat-shrunk around the screen's edge to protect the tube against the risk of implosion.

Finally, the deflection coil is slid over the neck, up to the cone. After various measurements and finishing operations, the deflection coil is set to ensure a uniform, equal distribution of the red, green and blue electron beams across the entire screen (called 'matching'). The deflection coil is then fixed in its final position.